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INVESTIGATION ON EFFECT OF TIN COATED AND UNCOATED HSS TOOLS FOR MACHINING AA6061

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ABSTRACT

Aluminum alloy 6061 was widely used in aircraft structures, yacht construction, automotive chassis, etc., For machining the Aluminum alloy 6061 high-speed steel (HSS) end mill cutters were used. When carbide end mills were used for the same it results in high durability and good wear characteristics but it is quite more expensive. In this research work, machining of aluminum alloy 6061 with Titanium nitride coated HSS end mills was attempted. The coating process was done by a physical vapor deposition method. Experiments were conducted in full factorial approach with keeping feed rate, speed and depth of cut as variables each of them has three levels. Wear characteristics were compared to machining using uncoated and coated end mill. The optimization process is carried out using Minitab software and the results were presented.

KEYWORDS: Aluminum Alloy 6061, High Speed Steel (HSS) End Mill Cutters, Titanium Nitride (TiN) & PVD Coating

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INTRODUCTION

Aluminium alloy 6061 will have silicon, magnesium, copper, and chromium as major alloying elements. The chemical composition of the work piece used in this investigation was tabulated below

Table 1: Chemical Composition of AA 6061

Element	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
Weight %	0.603	0.199	0.097	0.079	0.452	0.025	0.065	0.020	98.21

For machining of AA 6061 alloy HSS tools were generally preferred and we compared the machining with TiN coated HSS tool and uncoated HSS tool and average surface roughness were measured using the Tally surf machine.

Tin has a Vickers hardness of 1800–2100, a modulus of elasticity of 251 GPA, and a superconducting transition temperature of 5.6K. Tin will oxidize at 800 °C in a normal atmosphere. It is chemically stable at 20 °C, but can slowly be attacked by concentrating acid solutions with rising temperatures. Depending on the substrate material and surface finish, TiN will have a coefficient of friction ranging from 0.4-0.9 against another TiN surface (non-lubricated). The typical TiN formation has a crystal structure of NaCl-type.

A known use for Tin coating is used for sharp edge preservation and corrosive resistance on machine tools, such as drill bits and milling cutters, often which improve their life.

Since TiN's metallic gold color, it is used to coat costume jewelry and automotive trim for decorative purposes. Tin is also used as a top-layer coating, usually with nickel or chromium plated substrates, on door hardware. It is also used to protect the sliding surfaces of suspension forks of bicycles and motorcycles as well as the shock shafts of radio-controlled cars. Tin is non-toxic, it is seen in use in medical devices such as scalpel blades and orthopedic saw blades where the sharpness and the sharp edge preservation are very important.

Figure 1: TiN Coated and Uncoated HSS Tools used for Machining

Figure 2: AA6061 Work Pieces used for Machining

DESIGN OF EXPERIMENTS

Totally 54 experiments were carried out in wet environment using speed, feed rate and depth of cut as a primary parameter using full factorial design as an approach for optimization.

Table 2: Machining Parameters

Work Material	AA 6061
Speed (rpm)	2500, 3000, 3500
Feed rate (mm/rev)	20, 40, 60
Depth of cut (mm)	0.5, 0.75, 1.0
DoE	Full factorial Design
Machining Center	CNC Milling Center (Makino FX650)
Coating Thickness	4.129 microns
Tools Used	Uncoated HSS Four flute end mills, TiN Coated HSS Four flute end mills

RESULTS AND DISCUSSIONS

After conducting all the experiments surface roughness was measured using tally surf and the values were tabulated and shown in the table 3. Using Minitab software residual, interaction, main effect plot and optimization was obtained for both machining with TiN coated and uncoated HSS tool.

Table 3: Surface Roughness Values for TiN Coated and Uncoated HSS Tool

Speed (rpm)	Feed (rev / min)	Depth of Cut (mm)	Ra for TiN Coated HSS Tool	Ra for Uncoated HSS Tool
2500	20	0.5	0.7105	2.0425
		0.75	1.168	1.471
		1	0.335	2.7335
	40	0.5	1.123	0.2
		0.75	0.4615	2.3755
		1	0.555	4.602
	60	0.5	0.34	0.698
		0.75	0.281	0.254
		1	0.485	1.513
3000	20	0.5	0.939	0.33
		0.75	0.546	0.279
		1	2.0545	0.3055
	40	0.5	0.8345	0.5075
		0.75	0.6435	0.78
		1	0.822	1.2
	60	0.5	1.3885	0.884
		0.75	1.1405	1.265
		1	0.7505	0.7775
3500	20	0.5	0.5485	1.652
		0.75	0.605	1.0235
		1	0.659	1.3275
	40	0.5	0.9515	0.1462
		0.75	0.29	0.335
		1	1.605	0.188
	60	0.5	0.3165	0.1825
		0.75	1.4955	0.1825
		1	0.882	0.552

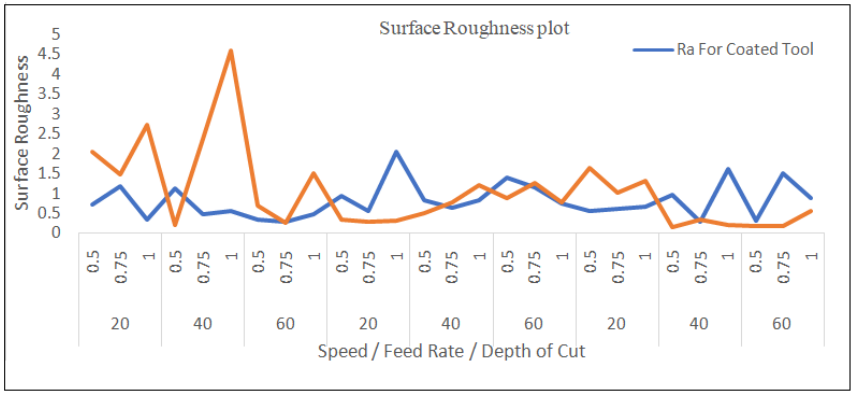
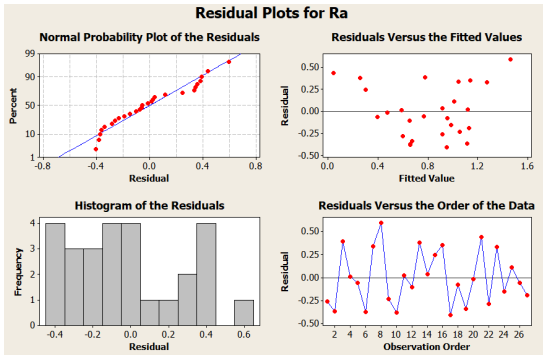
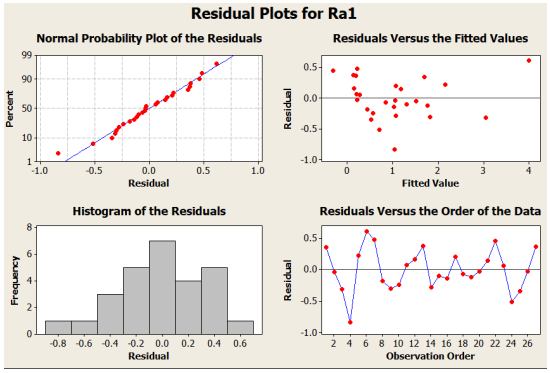
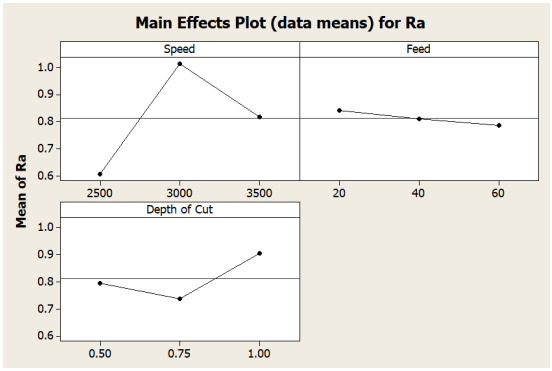
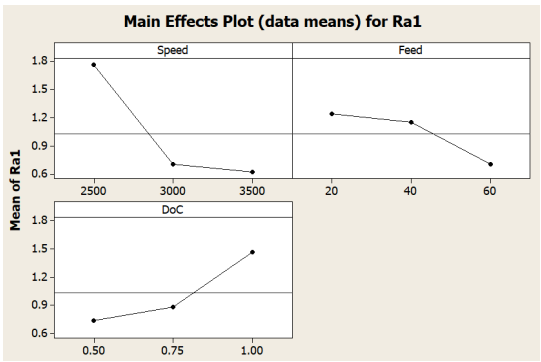
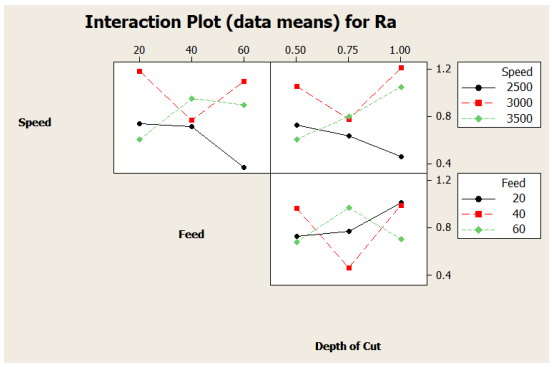
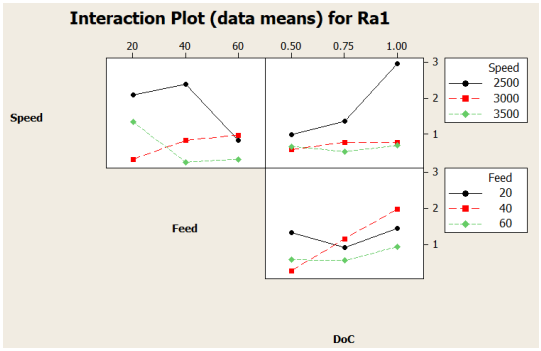


Figure 3: Comparison of Ra for TiN Coated and Uncoated HSS Tool

Table 4: Comparison of Various Plot for TiN Coated and Uncoated HSS Tool using Minitab

TiN Coated HSS Tool	UnCoated HSS Tool
	
	
	

CONCLUSIONS

The effect on Titanium nitride coated HSS 4 flute end mill cutters and uncoated HSS end mill cutters during milling of AA 6061 was studied and the following conclusions were presented.

The Average surface roughness value was found to be minimal when machining with TiN coated HSS end mills comparing with uncoated HSS end mills

Tin Coated HSS tool life was found to be increased when compared with uncoated HSS end mills

Average surface roughness value was increased when machining with a feed rate of 60 mm/rev in both cases. Hence, we can conclude that minimum feed rate level can be employed for machining.

After analyzing in the mini tab software tool, the optimal values for machining AA 6061 in the wet environment will be, a speed of 3500 rpm, depth of cut as 1.0 mm and feed rate as 20 mm/rev.

From the above-said observation, we can conclude that the Titanium Nitride coated HSS tool can achieve better at high cutting speeds when compared with uncoated tools which result in better surface finishing and longer tool life.

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